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TNT EQUIVALENCY OF EAK EXPLOSIVE

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This project was accomplished as part of the U.S. Army's Manufacturing Methods and Technology Program. The primary objective of this program is to develop, on a timely basis, manufacturing processes, techniques, and equipment for use in the production of Army materiel.

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Scaled positive impulse
Scaled distance
Peak pressure
Time of arrival
MMT-Safety

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Peak side-on blast overpressure and scaled positive impulse have been measured for EAK explosive. The equivalency testing addressed the cylindrical shipping container. High explosive equivalency values for each test series were obtained as a function of scaled distance by comparison to known pressure and impulse characteristics for TNT hemispherical surface bursts.

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SUMMARY

The insensitive high explosive EAK was detonated in a configuration that simulated its storage/shipping container. Blast output parameters were measured, and the TNT equivalency was computed based on the comparison with TNT hemispherical surface bursts. The results are shown below:

	TNT Equivalency (%) at Scaled Distance											
	1.19 $m/kg^{1/3}$ (3.0 $ft/lb^{1/3}$)		1.59 $m/kg^{1/3}$ (4.0 $ft/lb^{1/3}$)		2.14 $m/kg^{1/3}$ (5.4 $ft/lb^{1/3}$)		3.57 $m/kg^{1/3}$ (9.0 $ft/lb^{1/3}$)		7.14 $m/kg^{1/3}$ (18.0 $ft/lb^{1/3}$)		15.87 $m/kg^{1/3}$ (40.0 $ft/lb^{1/3}$)	
Configuration	P	I	P	I	P	I	P	I	P	I	P	I
Simulated shipping drum 11.34 kg (25 lb)	109	81	82	70	70	64	99	51	116	78	72	70
Simulated shipping drum 22.68 kg (50 lb)	98	99	92	56	81	68	130	67	116	68	100	83

Due to the insensitive characteristics of EAK, a 15% conically shaped composition C-4 booster had to be used to ensure a high order detonation. The pressure equivalencies ranged from a high of 130% to a low of 70%. The impulse equivalencies were less than 100%, ranging from a high of 99% to a low of 51%.

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INTRODUCTION

Background

The EAK intermolecular explosive is not a military standard explosive and no existing facilities are available for its production, therefore, explosive classification has not been specifically designated, either in its in-process or final form. The formulation has been designated as an insensitive high explosive (IHE) by the Air Force. It is presently a proposed filler for the standard MK82, GP (500 lb) bomb, and a modified formulation is proposed for large caliber projectile fills. Because the explosive is insensitive to shock, this may reduce the quantity-distance storage requirements. Also, EAK is easier to produce than TNT, and the raw materials used to make it are lower in cost, nonpetroleum based, and commercially available in large quantities, making it economically more attractive than TNT.

The chemical constituents of EAK by percent weight are:

Component	%
Ethylenediamine dinitrate	45.7
Ammonium nitrate	46.2
Potassium nitrate	8.1

The tests were conducted in accordance with the requirements of MMT Project 5860108 as an engineering effort to provide TNT equivalency data.

Objective

The objective of this test program was to determine the maximum output from the detonation of EAK in terms of the peak overpressure and positive impulse. The measured pressure and impulse data were compared with known TNT test data to determine the equivalency of EAK in relation to TNT.

EXPERIMENTAL METHODS

Materials

Test material was EAK high explosive. EAK was received from the Naval Weapons Station, Yorktown, Virginia, in metal

shipping drums. Each drum contained 90.7 kg (200 lbs) of EAK. The physical characteristics were chips of various thicknesses and dimensions.

Test Plan

EAK output was evaluated for weights and configurations simulating its shipping/storage container. The proposed shipping/storage container is a fiber drum 17 inches in diameter by 10 inches in height:

a. A cylindrical container (figure 1) with a charge weight of 11.34 kg (25 lb) of EAK was used to simulate the shipping/storage container with a dimensional scaling factor of 0.79. The container was constructed from fiberboard with a height of 20.1 cm (7.9 inches) and a diameter of 34.3 cm (13.5 inches).

b. A cylindrical container (figure 2) with a charge weight of 22.68 kg (50 lb) of EAK was used to simulate the shipping/storage container with a dimensional scaling factor of 1.0. The container was constructed from fiberboard with a height of 25.4 cm (10 inches) and a diameter of 43.2 cm (17.0 inches).

Each test charge was initiated with a J-2 blasting cap and a conically shaped booster of composition C-4 high explosive. It was necessary to use a 15% C-4 booster to achieve a complete detonation. The C-4 was shaped conically with an aspect ratio of 1:4 (H/W). The C-4 was centered on top of the EAK in the simulated shipping/storage container with the blasting cap inserted at the apex and embedded to the cone's center.

The test charge for each configuration was placed on a 1010 carbon-steel witness plate, 1.27 cm (0.5 inches) thick, with the outside dimension 15.2 cm (6 inches) larger than the base of the test configuration dimensions. Figure 3 shows the test area. The area was refurbished after each test subsequent to measurement of crater diameter and depth.

Instrumentation

Twelve side-on pressure transducers were mounted and placed at ground level in two 90-degree arrays within the test area shown in figure 3. Distances between the transducers and charge were calculated to correspond to scaled distances of 1.19, 1.59, 2.14, 3.57, 7.14 and 15.87 $m/kg^{1/3}$ (3.0, 4.0, 5.4, 9.0, 18.0 and 40.0 $ft/lb^{1/3}$). The transducers were individually calibrated prior to each test series with quasistatic pressure pulses, using a

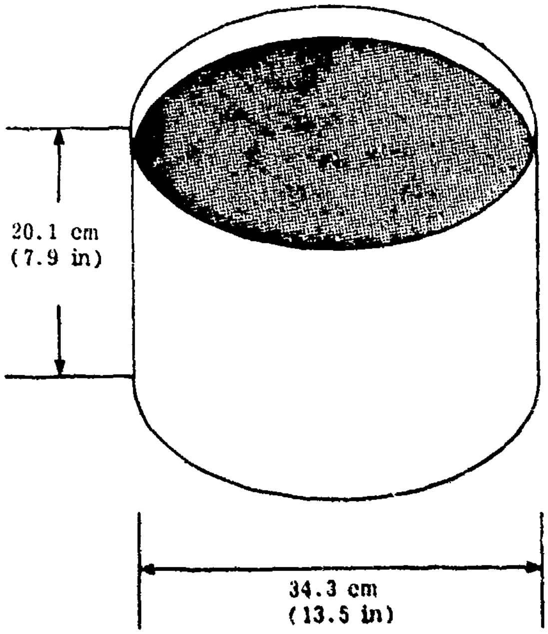


Figure 1. Simulated scaled shipping/storage container 11.34 kg (25 lb)

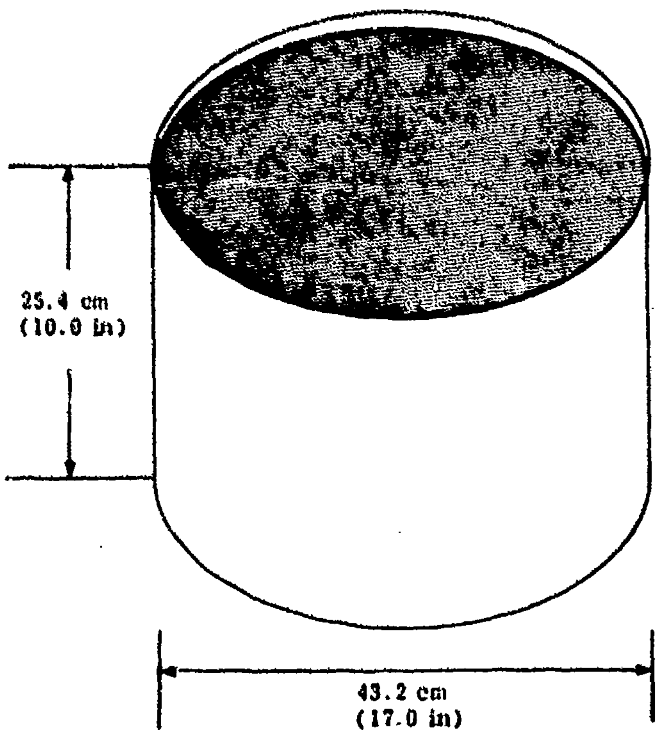


Figure 2. Simulated full scale shipping/storage container 22.68 kg (50 lb)

standard solenoid-actuated air-pressure calibration fixture adjusted to correspond to expected overpressure based on an assumed TNT equivalency of 100%. Signal-line continuity and channelization were checked prior to each test. Details of distances between charge and transducers, calibration pressures, and expected peak overpressures at each distance are shown in table 1.

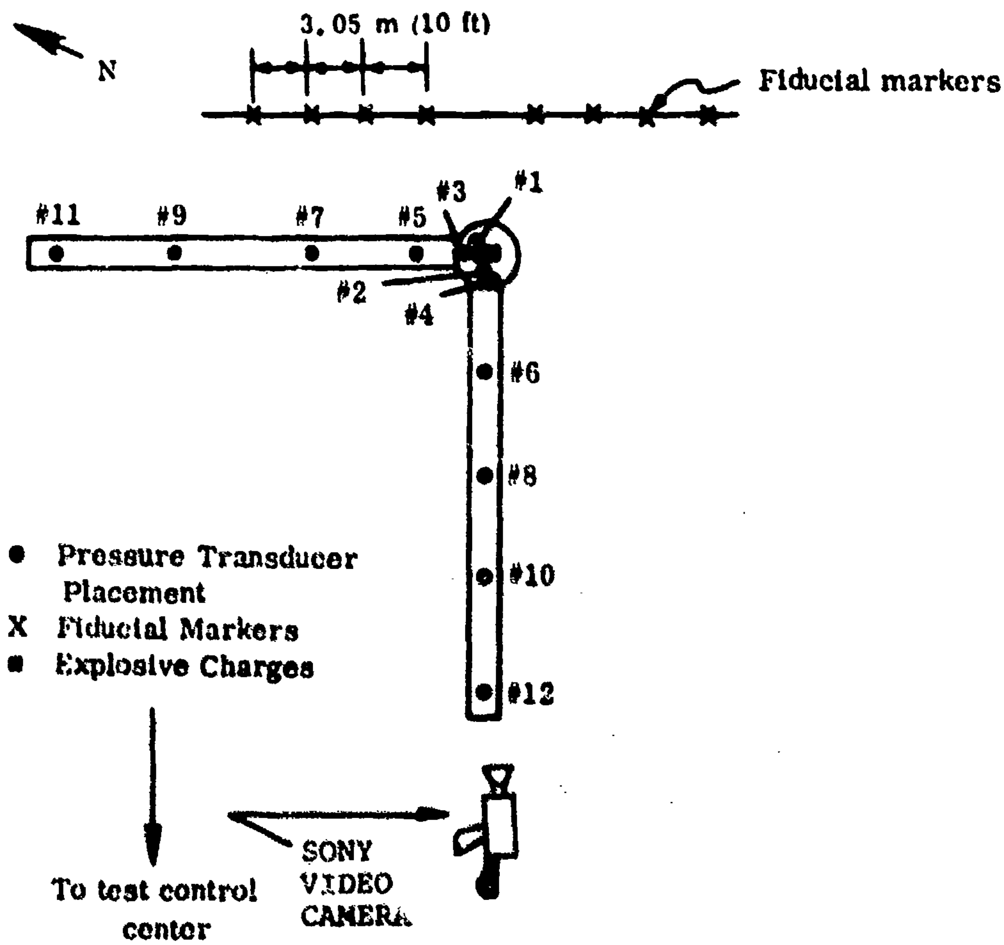


Figure 3. Test area showing charge placement, transducer placement, and camera placement

Signals were recorded using six two-channel and two four-channel Nicolet Explorer digital oscilloscopes. A complete description of the recording system is given in Appendix A. These digital oscilloscopes offer the ability to capture, store, and display one-shot transient signals with both pre- and post-trigger information. Ionization probes were used to trigger the Nicolets and get T_o. for time of arrival data.

Before and after color still photographs were taken of each test, showing typical setup and results. Standard meteorological data were recorded for each test. Video coverage of each test was also recorded.

Table 1. Transducer calibration and placement of EAK

Channel number	Scaled distance $m/kg^{1/3}$ ($ft/lb^{1/3}$)	Expected pressure kPa (psi)	Calibration pressure kPa (psi)	100% Over calibration pressure kPa (psi)	Radial distance m (ft)	
					Charge weight 11.34 kg (25 lb)	Charge weight 22.68 kg (50 lb)
1,2	1.19 (3)	922 (133.71)	2068.5 (300)	4137.4 (600)	2.67 (8.77)	3.37 (11.05)
3,4	1.59 (4)	479.8 (69.58)	1034.3 (150)	2068.5 (300)	3.57 (11.70)	4.49 (14.74)
5,6	2.14 (5.4)	242.5 (35.17)	517.2 (75)	1034.3 (150)	4.81 (15.79)	6.06 (19.89)
7,8	3.57 (9)	81.5 (11.82)	103.4 (15)	206.9 (30)	8.02 (26.32)	10.11 (33.16)
9,10	7.14 (18)	24.07 (3.49)	34.5 (5)	69.0 (10)	16.04 (52.63)	20.21 (66.31)
11,12	15.9 (40)	8.14 (1.18)	13.8 (2)	27.6 (4)	35.65 (116.96)	44.92 (147.36)

RESULTS

Data Analysis

Peak overpressure and positive impulse information were acquired in digital form. Data that could be attributed to instrumentation or explosive malfunction were excluded. The mean and standard deviation were then obtained and all data which fell outside two standard deviations were excluded from the TNT equivalency calculations. The data were then compared to data from TNT hemispheres.[1] A computer program was employed which utilized an iterative process that factors out the contribution of the booster charge weight and calculates the pressure and impulse equivalencies.[2] The calculated TNT equivalencies were arranged in tabular form and plotted as functions of sample scaled distance. The standard curve for TNT hemisphere reference data is shown in figure 4.

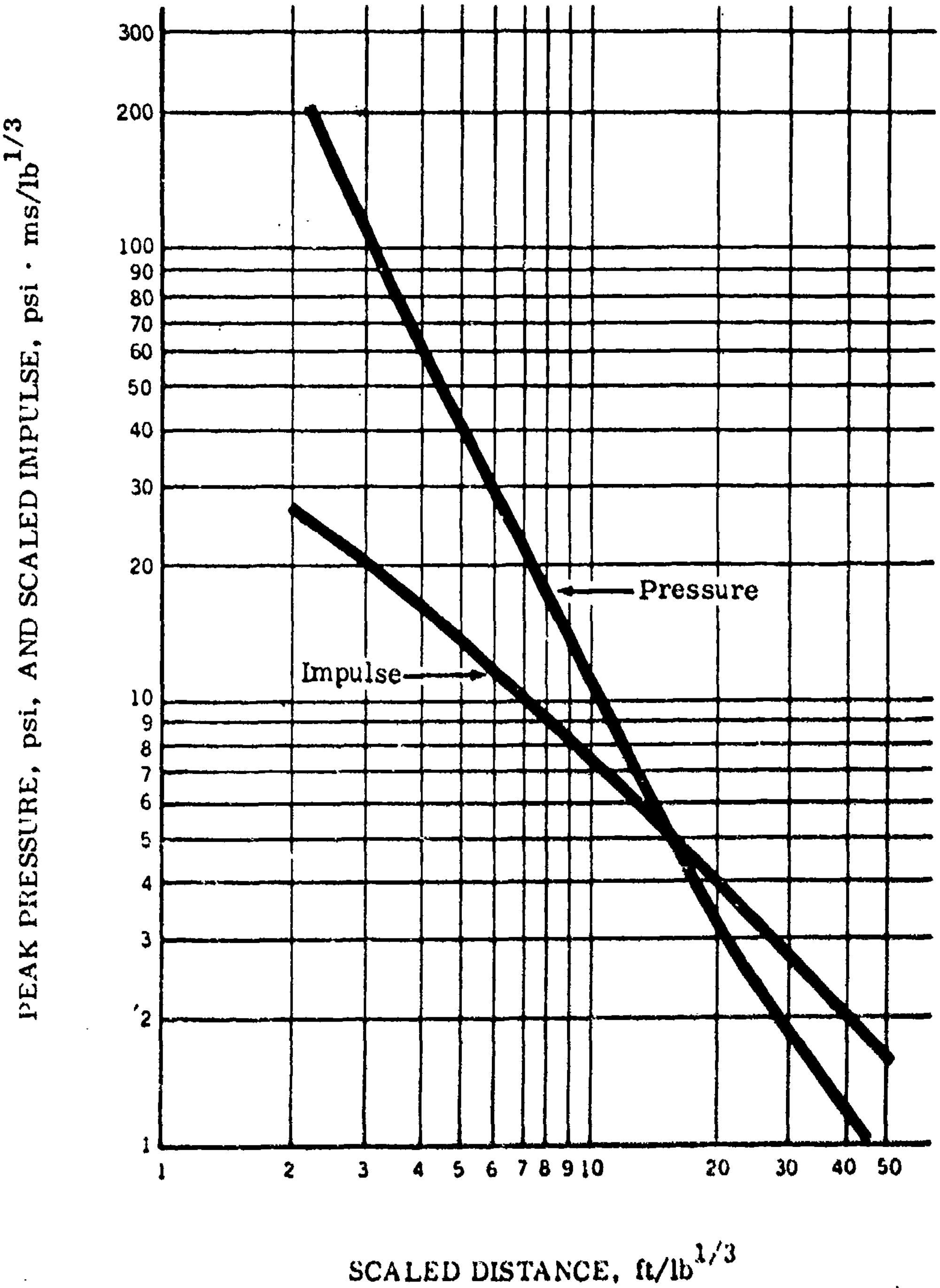


Figure 4. TNT hemisphere reference data

Test Results

A description of the instrumentation system is given in Appendix A. Data sheets for all tests with pertinent measured parameters are given in Appendix B. Selected pretest and posttest still photographs are shown in Appendix C. Test numbers are shown for local reference only and provide access to original range data files.

Mean pressure scaled positive impulse, and TNT equivalency data are summarized by test configuration in tables 2 and 3. Figures 5 and 7 show the plots of peak pressure, and scaled positive impulse versus scaled distance. Figures 6 and 8 show the plots of TNT equivalency versus scaled distance for peak pressure and scaled positive impulse by test configuration. The deviation from cube root scaling is shown in figure 9.

Discussion

Plots of peak pressure and scaled positive impulse for the simulated shipping/storage container with a charge weight of 11.34 kg (25 lb) are shown in figure 5. The plots of TNT equivalencies for pressure and scaled positive impulse are shown in figure 6. Pressure values were less than expected. Only at scaled distances of 1.19 m/kg$^{1/3}$ (30 ft/lb$^{1/3}$) and 7.14 m/kg$^{1/3}$ (18.0 ft/lb$^{1/3}$) were the pressure equivalency values greater than 100%. Scaled positive impulse values were lower than expected at all scaled distances. The impulse TNT equivalency values were all less tan 100%, ranging from a high of 81% at a scaled distance of 1.19 m/kg$^{1/3}$ (3.0 ft/lb$^{1/3}$) to a low of 51% at a scaled distance of 3.57 m/kg$^{1/3}$ (9.0 ft/lb$^{1/3}$).

Plots of peak pressure and scaled positive impulse for the simulated shipping/storage container with a charge weight of 22.68 kg (50 lb) are shown in figure 7. The plots of TNT equivalencies for pressure and scaled positive impulse are shown in figure 8. Pressure values were less than expected at the near-field scaled distances, $\leq$ 2.14 m/kg$^{1/3}$ (5.4 ft/lb$^{1/3}$), and greater at the far-field scaled distances, $\geq$ 3.57 m/kg$^{1/3}$ (9.0 ft/lb$^{1/3}$). Therefore, pressure equivalencies were less than 100% at the near-field scaled distances, $\leq$ 2.14 m/kg$^{1/3}$ (5.4 ft/lb$^{1/3}$), and greater than 100% at the far-field scaled distances, $\geq$ 3.57 m/kg$^{1/3}$ (9.0 ft/lb$^{1/3}$). Scaled positive impulse values were less than expected at all scaled distances. Therefore, the impulse TNT equivalency values were all less than 100%.

Table 2. Summary of test results, 11.34 kg (25 lb) charge in a cylindrical shipping container

Radius meters (ft)	Scaled distance $m/kg^{1/3}$ $(ft/lb^{1/3})$	Peak pressure kPa (psi)	Scaled positive impulse $kPa\ ms/kg^{1/3}$ $(psi\ ms/lb^{1/3})$	Pressure TNT equivalency (%)	Impulse TNT equivalency (%)
2.67 (8.77)	1.19 (3)	1072 (155.47)	155.7 (17.35)	109	81
3.57 (11.70)	1.59 (4)	475.2 (68.92)	114 (12.70)	82	70
4.81 (15.79)	2.14 (5.4)	221.7 (32.15)	85.7 (9.55)	70	64
8.02 (26.32)	3.57 (9)	88.6 (12.85)	48.5 (5.40)	99	51
16.04 (52.63)	7.14 (18)	27.7 (4.02)	32.8 (3.65)	116	78
35.65 (116.96)	15.87 (40)	7.8 (1.13)	14.6 (1.63)	72	70

Table 3. Summary of test results, 22.68 kg (50 lb) charge in a cylindrical shipping container

Radius meters (ft)	Scaled distance $m/kg^{1/3}$ $(ft/lb^{1/3})$	Peak pressure kPa (psi)	Scaled positive impulse $kPa\ ms/kg^{1/3}$ $(psi\ ms/lb^{1/3})$	Pressure TNT equivalency (%)	Impulse TNT equivalency (%)
3.37 (11.05)	1.19 (3)	1012.3 (146.81)	177.2 (19.75)	98	99
4.49 (14.74)	1.59 (4)	517.3 (75.02)	102.9 (11.47)	92	56
6.06 (19.89)	2.14 (5.4)	245.3 (35.58)	89.3 (9.95)	81	68
10.11 (33.16)	3.57 (9)	105.7 (15.33)	57.3 (6.39)	130	67
20.21 (66.31)	7.14 (18)	27.7 (4.02)	28.5 (3.18)	116	68
44.92 (147.36)	15.87 (40)	8.8 (1.28)	16.1 (1.79)	100	83

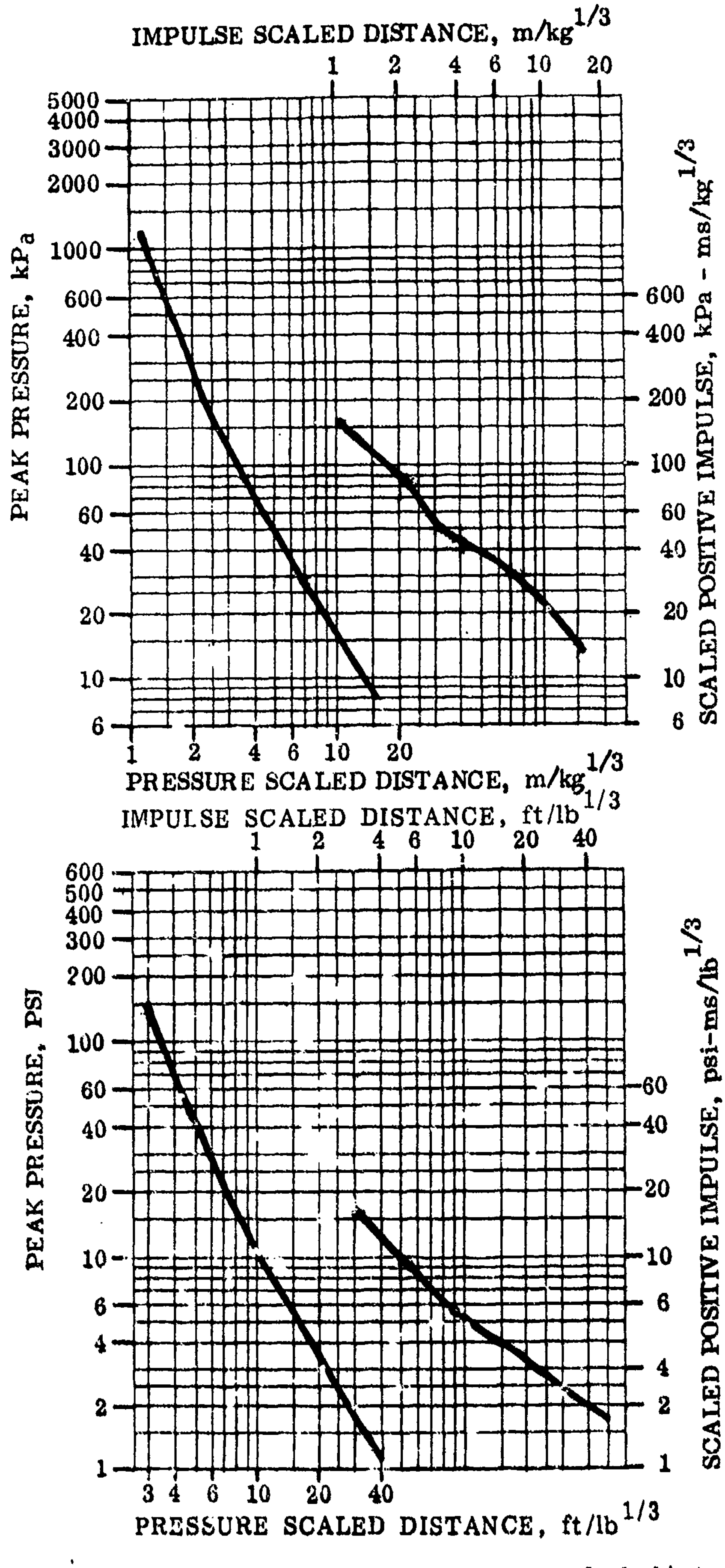


Figure 5. Pressure and impulse versus scaled distance for 11.34 kg (25 lb) charge of EAK in cylindrical shipping container

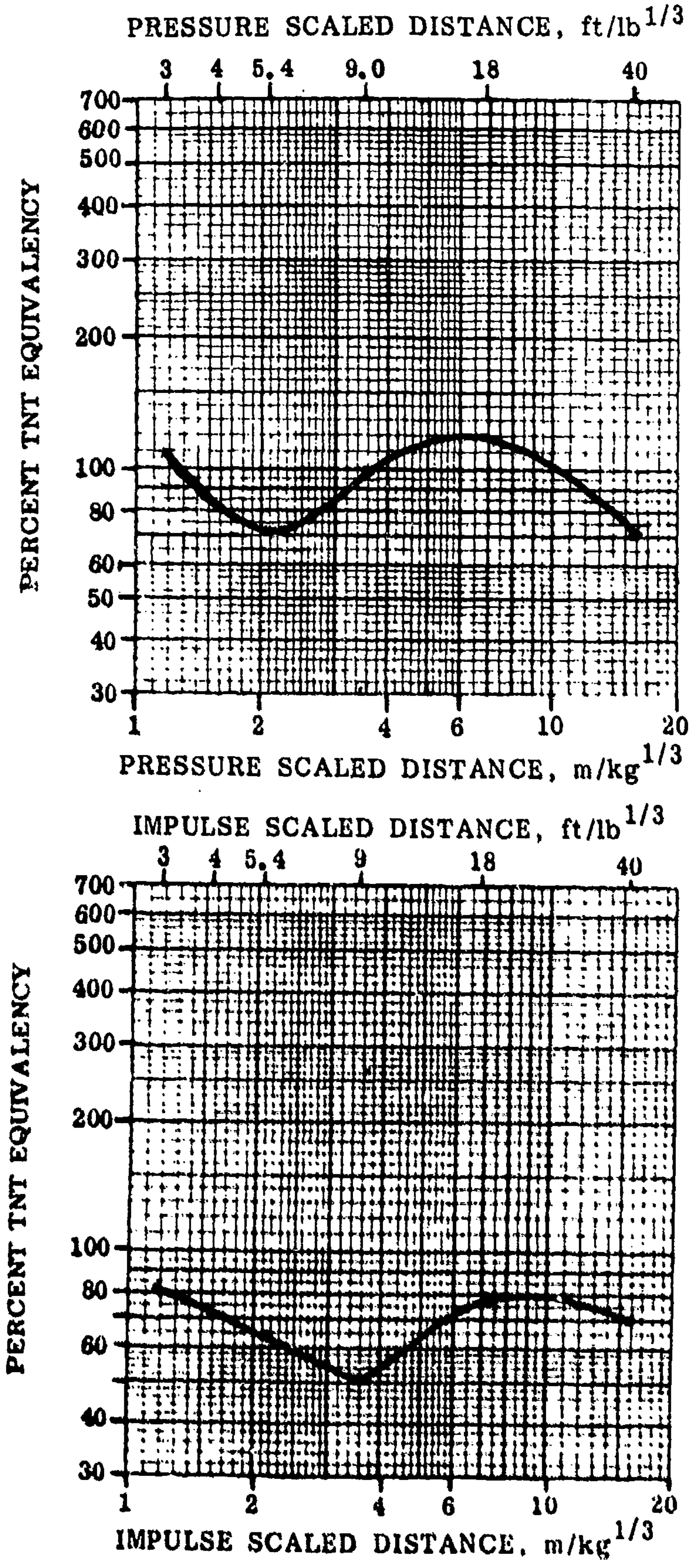
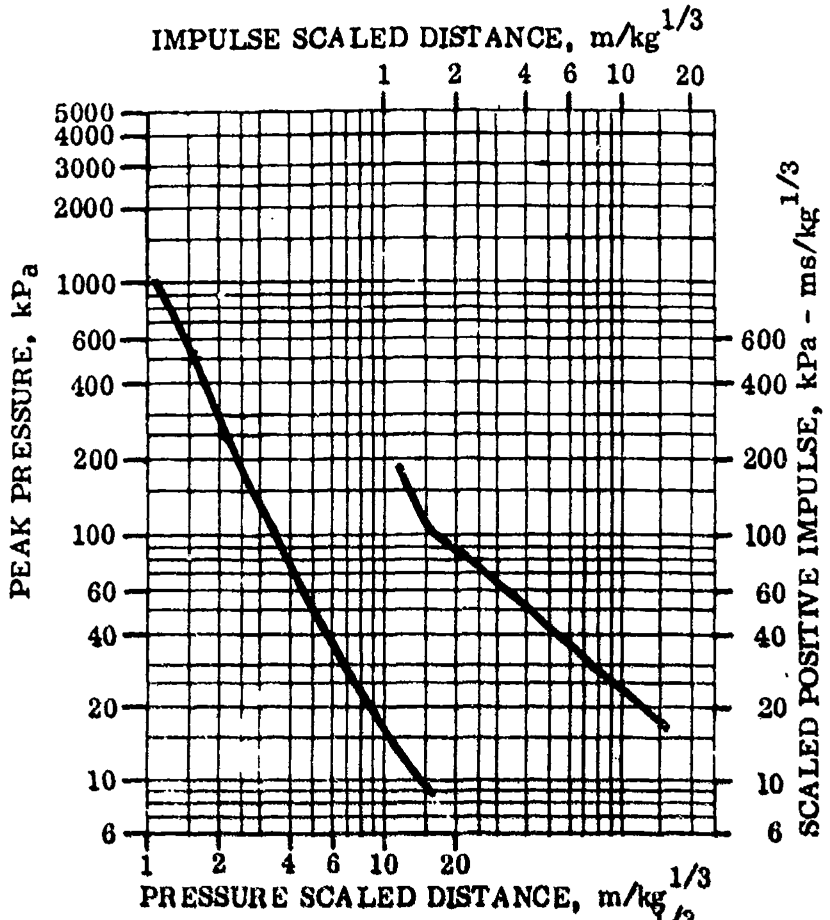


Figure 6. Pressure and impulse TNT equivalency for 11.34 kg (25 lb) charge of EAK in a cylindrical shipping container



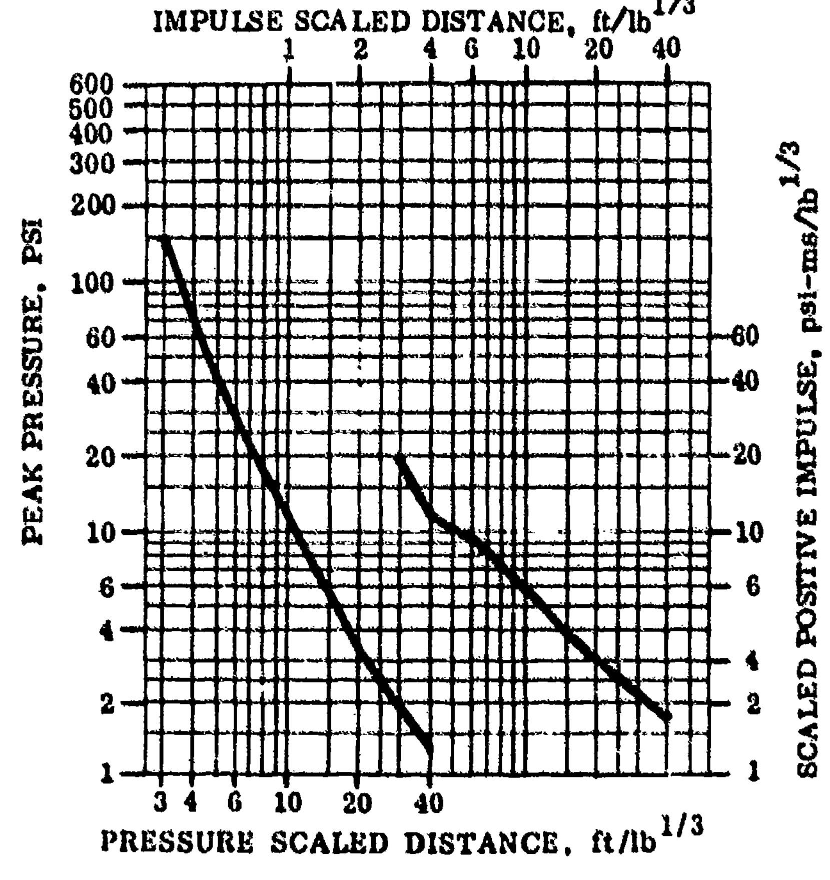
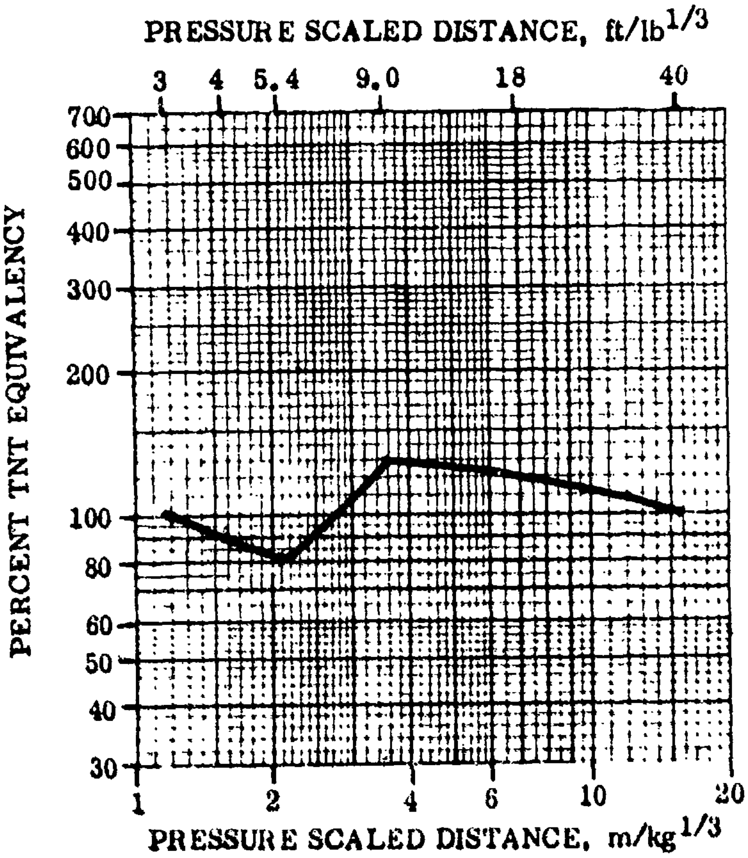


Figure 7. Pressure and impulse versus scaled distance for 22.68 kg (50 lb) charge of EAK in a cylindrical shipping container



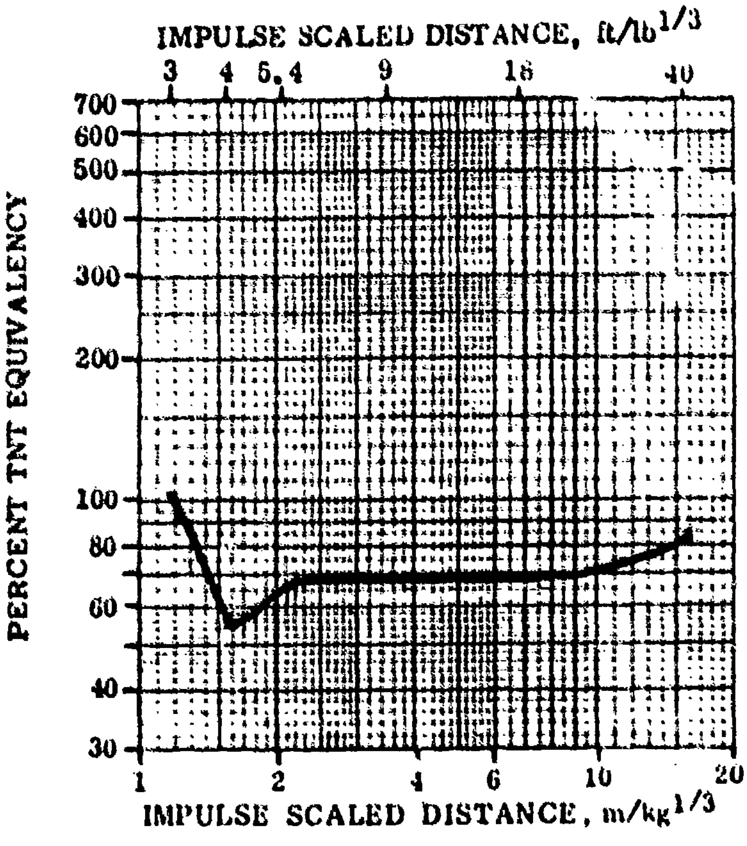


Figure 8. Pressure and impulse TNT equivalency for 22.68 kg (50 lb) charge of EAK in a cylindrical shipping container

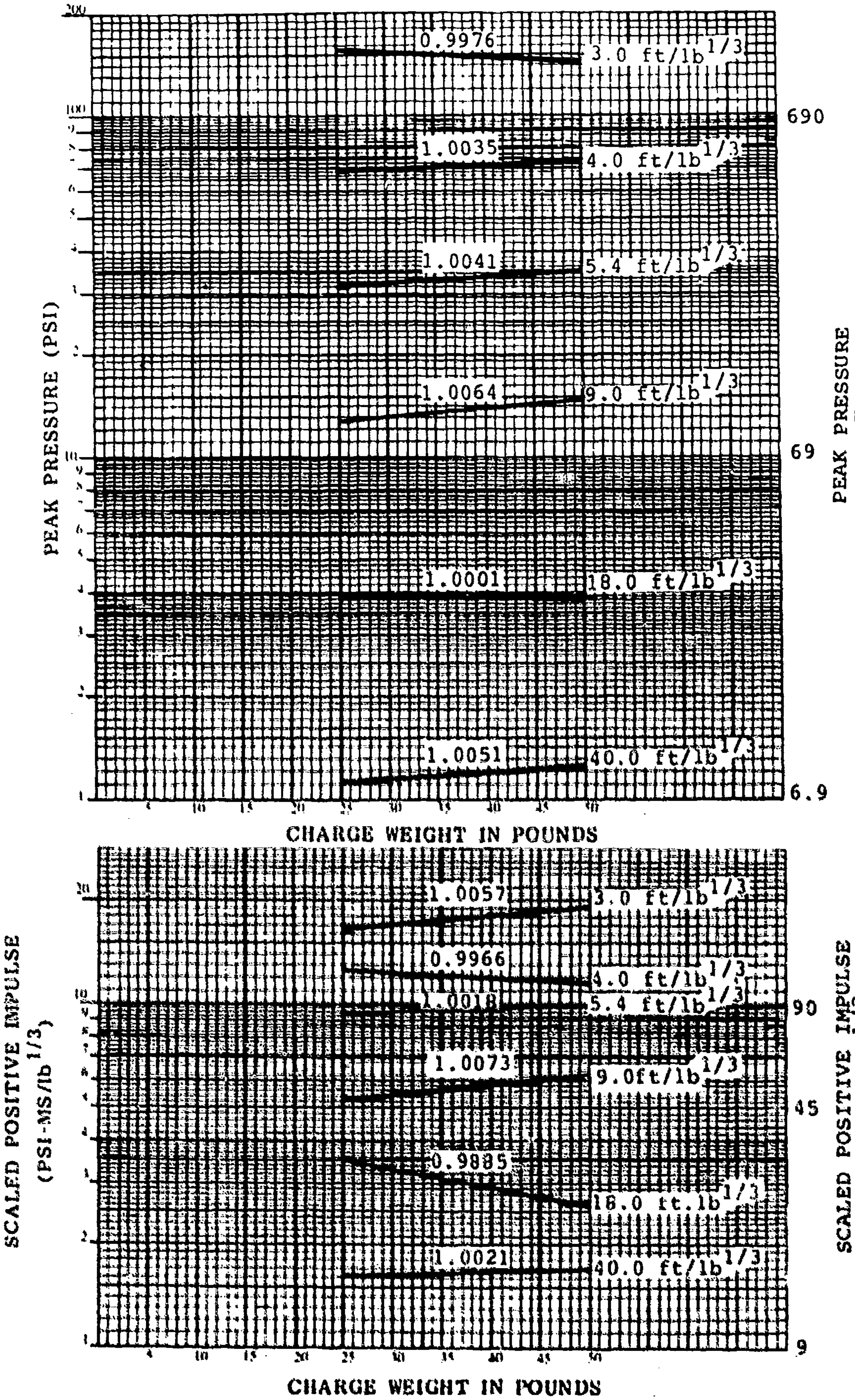


Figure 9. Deviation from cube root scaling

Plots of peak pressure and scaled positive impulse for the 11.34 kg (25 lb) charge and the 22.68 kg (50 lb) charge in a simulated shipping/storage container show the same general trend. The plots of TNT equivalency values for pressure and scaled positive impulse show the same general trend. The EAK formulation was designated to be an insensitive high explosive, and the test results confirm this in that a booster of 15% was required to achieve a complete detonation.

Figure 9 shows the deviation from cube root scaling as a function of the charge weight. Theoretically, a given output will occur at a distance from an explosion that is proportional to the cube root of the energy yield (known as cube root scaling or Hopkinson's scaling).[3] With the aid of such a law, it is possible to present data for a large range of weights in a simple form, and by the use of scaled distances, one is able to calculate properties of an explosion of any given energy, if those for another energy are known. By the use of cube root scaling, one can determine if output is increasing or decreasing with charge weight. To what degree the output is increasing or decreasing can be determined by performing a least squares linear regression analysis, which is designed to minimize the sum of the squares of the deviations of the actual data points from the straight line of best fit. A slope of one (1) for this line would indicate, by definition, that the data scales. An increase in output with increasing charge weight would be indicated by a positive slope. A decrease in output with increasing charge weight would be indicated by a negative slope. Equal rise and fall in the slope of the line indicates equal percentage changes. For EAK in a cylindrical shipping container, the slopes of the line for deviation from "cube root scaling" for peak pressure at each scaled distance, as a function of charge weight, ranged from a negative slope of 0.9976 to a positive slope of 1.0064. The slopes of the line for deviation from "cube root scaling" for scaled positive impulse at each scaled distance, as a function of charge weight, ranged from a negative slope of 0.9885 to a positive slope of 1.0073.

All of the information presented in this report is based on experimental data. As with any result based on experimental data, there is an inherent scatter involved; that is, the curves and tables presented represent the "best fit" or average values of the data, with some associated error band.

CONCLUSIONS

1. The blast output from EAK is dependent upon the configuration from which it detonates.

2. TNT equivalency values were determined for EAK in configurations that simulate the cylindrical shipping container.

3. To within experimental limits, blast pressure and impulse scale as a cube root function of the charge weight.

4. The pressure equivalency of EAK explosive as determined in this test series ranged from a high of 130% to a low of 70%. The impulse equivalency is less than 100% for all scaled distances.

RECOMMENDATIONS

1. In order to design meaningful experiments and for the resulting data to be intelligently applied, it is important that the many factors and parameters that affect the airblast be recognized and the data be used in the context in which they were derived.

2. The TNT equivalency of pressure and impulse values determined by the test series should be used in the structural design of protective facilities.

3. EAK should be tested in the configurations that are typical for a manufacturing facility.

4. For close-in structural design (scaled distances generally less than 3 $ft/lb^{1/3}$), values generated by this test program should not be used. A method for determining the TNT spherical equivalent weight is to multiply the charge weight by an equivalency from the ratios of the heats of detonation. Then a factor must be determined for the effect of charge shape. Some sources for this data are in references 4-5.

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4. Wisotski, John, and Snyer, W. H. "Characteristics of Blast Wave Obtained from Cylindrical High Explosive Charge," Denver Research Institute, November 1965.

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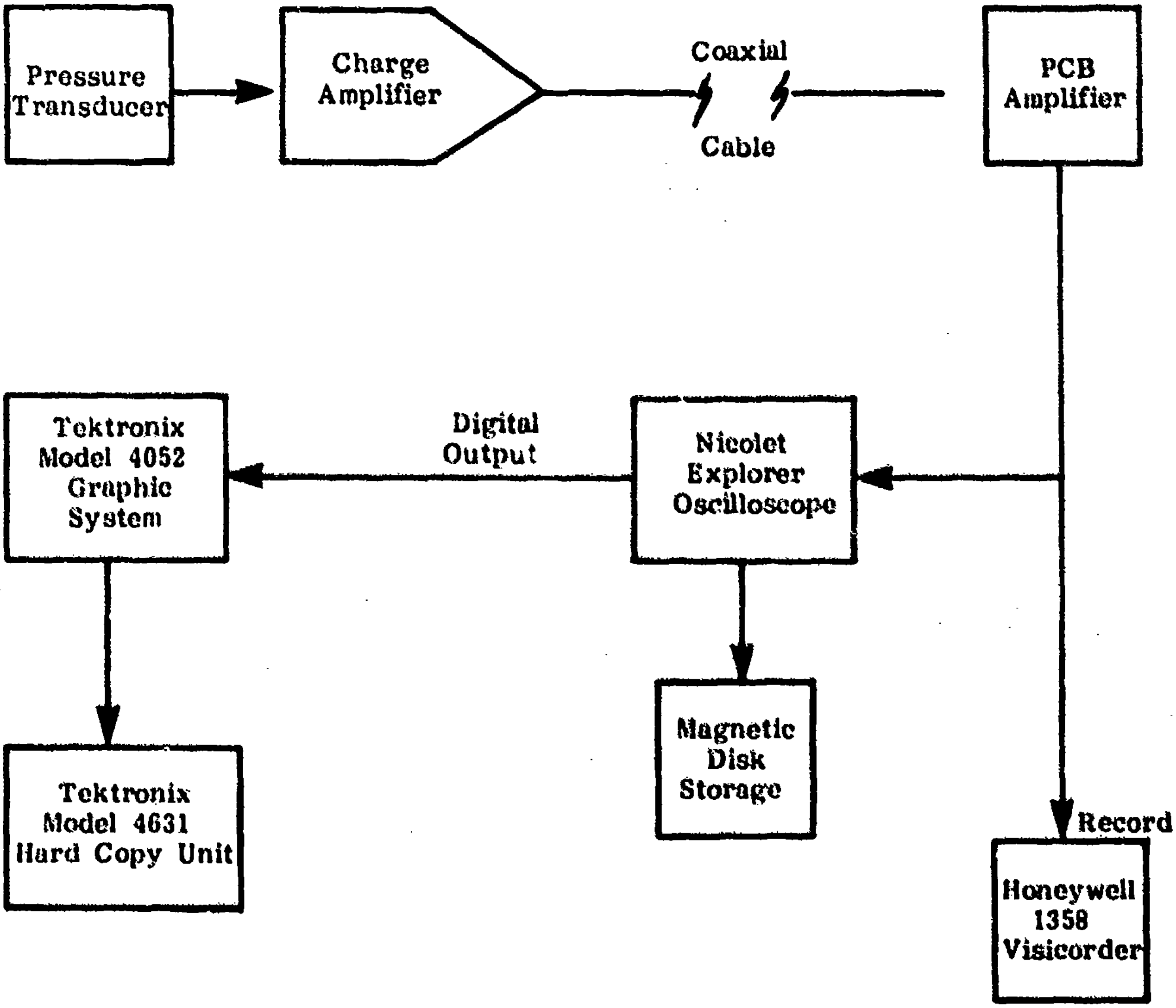
APPENDIX A

INSTRUMENTATION

Twelve PCB Piezotronics side-on pressure transducers were mounted flush to the surface in each of two sand-filled arrays within the test area. Each transducer was connected by an underground coaxial cable system into the instrumentation building approximately 800 feet from the test area. All signals were amplified by a model 494A06 PCB amplifier and recorded simultaneously on dual channel Nicolet Explorer oscilloscopes and a Honeywell 1858 visicorder. The Nicolet Explorer oscilloscopes were chosen because of their performance; they also provide a wide choice of options and measurement capabilities. It is basically a two-channel, 500 kHz oscilloscope having a writing rate of 5 cm/μsec, rise time of 500 ns and high resolution. It is useful in transducer measurements in providing direct electrical signal measurements, and with the built-in magnetic disk recorder, has the capability of storing signal waveforms for quick and easy recall. The Nicolet Explorer oscilloscopes were interfaced to a Tektronix 4052 graphic system and the peak blast overpressure and positive impulse information were obtained in digital form. The Honeywell 1858 visicorder was operated at 160 inches per second along with a 1 kHz timing pulse.



APPENDIX B

DATA SHEETS

TEST TITLE TNT EQUIVALENCY DATE 31 OCT 1984

TEST SAMPLE EAK EXPLOSIVE TIME

SAMPLE WEIGHT 11.34 kg (25 lb) TEMP.

IGN. SOURCE J2 BLASTING CAP HUMIDITY

BOOSTER WT. 1.13 kg (2.5 lb) BAR. PRESS.

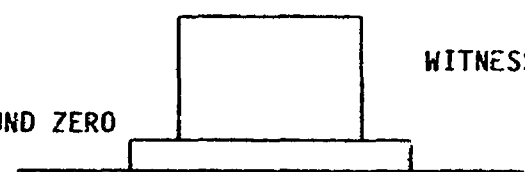
TEST NO. 44-84-05 WIND DIR.

CONTRACT NO. NAS 13-50 WIND VEL.

BOOSTER CHARGE
COMP. C4
CONICALLY SHAPED

L/D = 0.59

INITIATOR
J-2 CAP



FIELD EVALUATION

CHANNEL NUMBER	DISTANCE meters (ft)	PEAK PRESSURE kPa (psi)	SCALED POSITIVE IMPULSE kPa msec/kg$^{1/3}$ (psi msec/lb$^{1/3}$)	TIME OF ARRIVAL (msec)
1	2.67	910.1 (132.0)	250.9 (27.96)	1.57
2	(8.77)	1075.6 (156.0)	173.6 (19.35)	1.60
3	3.57	494.5 (71.72)	169.5 (18.89)	2.70
4	(11.70)	353.0 (51.20)	139.3 (15.52)	2.83
5	4.81	206.9 (30.0)	77.1 (8.59)	4.74
6	(15.79)	217.2 (31.5)	93.7 (10.44)	5.14
7	8.02	82.1 (11.90)	43.5 (4.85)	12.01
8	(26.32)	96.1 (13.94)	48.7 (5.43)	12.08
9	16.04	--	--	--
10	(52.63)	--	--	--
11	35.65	--	--	--
12	(116.96)	--	--	--

TEST TITLE TNT EQUIVALENCY DATE 31 OCT 1984

TEST SAMPLE EAK EXPLOSIVE TIME ______

SAMPLE WEIGHT 11.34 kg (25 lb) TEMP. ______

IGN. SOURCE J2 BLASTING CAP HUMIDITY ______

BOOSTER WT. ____ kg (3.0 lb) BAR. PRESS. ______

TEST NO. 44-84-06 WIND DIR. ______

CONTRACT NO. NAS 13-50 WIND VEL. ______

BOOSTER CHARGE
COMP. C4
CONICALLY SHAPED

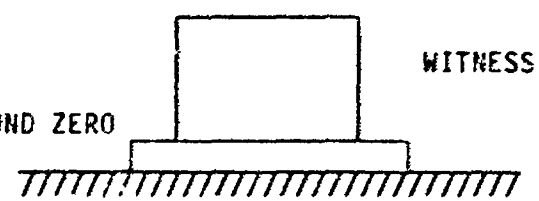
L/D = 0.59

INITIATOR

J-2 CAP

WITNESS PLATE

GROUND ZERO



NOT DRAWN TO SCALE

FIELD EVALUATION

CHANNEL NUMBER	DISTANCE meters (ft)	PEAK PRESSURE kPa (psi)	SCALED POSITIVE IMPULSE kPa msec/kg$^{1/3}$ (psi msec/lb$^{1/3}$)	TIME OF ARRIVAL (msec)
1	2.67	1075.6 (156.00)	149.4 (16.65)	1.61
2	(8.77)	1034.3 (150.00)	144.9 (16.15)	1.52
3	3.57	539.5 (78.24)	93.9 (10.46)	2.73
4	(11.70)	551.6 (80.00)	91.7 (10.22)	2.60
5	4.81	227.5 (33.0)	75.7 (8.43)	4.81
6	(15.79)	268.9 (39.00)	88.9 (9.91)	4.72
7	8.02	77.4 (11.22)	60.7 (6.76)	11.68
8	(26.32)	84.4 (12.24)	63.4 (7.07)	11.55
9	16.04	29.5 (4.28)	37.7 (4.20)	31.62
10	(52.63)	28.5 (4.14)	23.3 (2.60)	32.12
11	35.65	8.1 (1.17)	18.0 (2.01)	85.20
12	(116.96)	6.8 (0.98)	13.2 (1.47)	86.40

TEST TITLE TNT EQUIVALENCY DATE 1 NOV 1984

TEST SAMPLE EAK EXPLOSIVE TIME ______

SAMPLE WEIGHT 11.34 kg (25 lb) TEMP. ______

IGN. SOURCE J2 BLASTING CAP HUMIDITY ______

BOOSTER WT. ______ kg (3.75 lb) BAR. PRESS. ______

TEST NO. 44-84-07 WIND DIR. ______

CONTRACT NO. NAS 13-50 WIND VEL. ______

BOOSTER CHARGE
COMP. C4
CONICALLY SHAPED

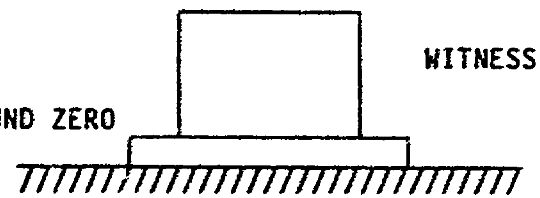
L/D = 0.59

INITIATOR

J-2 CAP

WITNESS PLATE

GROUND ZERO



NOT DRAWN TO SCALE

FIELD EVALUATION ______

CHANNEL NUMBER	DISTANCE meters (ft)	PEAK PRESSURE kPa (psi)	SCALED POSITIVE IMPULSE kPa msec/kg$^{1/3}$ (psi msec/lb$^{1/3}$)	TIME OF ARRIVAL (msec)
1	2.67	1034.3 (150.00)	159.6 (17.78)	1.52
2	(8.77)	951.5 (138.00)	140.4 (15.65)	1.60
3	3.57	485.4 (70.40)	95.2 (10.61)	2.62
4	(11.70)	430.2 (62.40)	89.5 (9.97)	2.77
5	4.81	165.5 (24.0)	73.3 (8.17)	4.72
6	(15.79)	248.2 (36.00)	102.9 (11.47)	4.84
7	8.02	96.1 (13.94)	49.4 (5.50)	11.44
8	(26.32)	96.1 (13.94)	31.9 (3.56)	11.48
9	16.04	21.6 (3.13)	21.5 (2.40)	31.75
10	(52.63)	29.1 (4.22)	36.5 (4.07)	31.85
11	35.65	7.0 (1.02)	12.7 (1.41)	85.20
12	(116.96)	7.4 (1.07)	15.4 (1.72)	85.60

TEST TITLE TNT EQUIVALENCY DATE 7 NOV 1984

TEST SAMPLE EAK EXPLOSIVE TIME ______

SAMPLE WEIGHT 11.34 kg (25 lb) TEMP. ______

IGN. SOURCE J2 BLASTING CAP HUMIDITY ______

BOOSTER WT. ____ kg (3.75 lb) BAR. PRESS. ______

TEST NO. 45-84-04 WIND DIR. ______

CONTRACT NO. NAS 13-50 WIND VEL. ______

BOOSTER CHARGE
COMP. C4
CONICALLY SHAPED

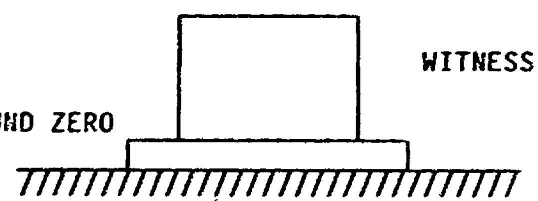
L/D = 0.59

INITIATOR

J-2 CAP

WITNESS PLATE

GROUND ZERO



NOT DRAWN TO SCALE

FIELD EVALUATION

CHANNEL NUMBER	DISTANCE meters (ft)	PEAK PRESSURE kPa (psi)	SCALED POSITIVE IMPULSE kPa msec/kg$^{1/3}$ (psi msec/lb$^{1/3}$)	TIME OF ARRIVAL (msec)
1	2.67	1097.1 (159.12)	181.5 (20.23)	1.67
2	(8.77)	951.5 (138.00)	145.7 (16.24)	1.64
3	3.57	441.3 (64.00)	109.2 (12.17)	2.90
4	(11.70)	507.5 (73.60)	98.0 (10.92	2.84
5	4.81	224.1 (32.50)	67.3 (7.50)	4.94
6	(15.79)	244.8 (35.50)	100.0 (11.14)	4.93
7	8.02	82.1 (11.90)	73.6 (8.20)	11.66
8	(26.32)	105.5 (15.30)	38.7 (4.31)	11.60
9	16.04	33.3 (4.83)	22.5 (2.51)	32.00
10	(52.63)	21.9 (3.17)	32.8 (3.65)	32.20
11	35.65	8.3 (1.20)	15.3 (1.70)	86.70
12	(116.96)	8.6 (1.25)	16.6 (1.85)	86.90

TEST TITLE TNT EQUIVALENCY DATE 7 NOV 1984

TEST SAMPLE EAK EXPLOSIVE TIME ______

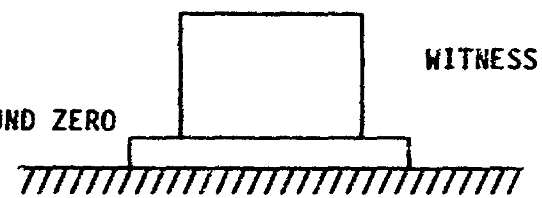
SAMPLE WEIGHT 11.34 kg (25 lb) TEMP. ______

IGN. SOURCE J2 BLASTING CAP HUMIDITY ______

BOOSTER WT. ____ kg (3.75 lb) BAR. PRESS. ______

TEST NO. 45-84-05 WIND DIR. ______

CONTRACT NO. NAS 13-50 WIND VEL. ______



FIELD EVALUATION ______

CHANNEL NUMBER	DISTANCE meters (ft)	PEAK PRESSURE kPa (psi)	SCALED POSITIVE IMPULSE kPa msec/kg$^{1/3}$ (psi msec/lb$^{1/3}$)	TIME OF ARRIVAL (msec)
1	2.67	1265.9 (183.60)	101.4 (11.30)	1.47
2	(8.77)	1323.8 (192.00)	109.4 (12.19)	1.66
3	3.57	485.4 (70.40)	127.0 (14.15)	2.69
4	(11.70)	463.3 (67.20)	126.7 (14.12)	2.82
5	4.81	188.2 (27.30)	77.6 (8.65)	4.79
6	(15.79)	225.2 (32.66)	100.2 (11.17)	5.01
7	8.02	70.3 (10.20)	46.2 (5.15)	11.70
8	(26.32)	96.1 (13.94)	28.5 (3.18)	11.66
9	16.04	35.2 (5.11)	57.4 (6.40)	31.85
10	(52.63)	22.7 (3.29)	30.4 (3.39)	32.50
11	35.65	7.9 (1.15)	13.0 (1.45)	86.50
12	(116.96)	8.3 (1.20)	13.1 (1.46)	87.20

TEST TITLE TNT EQUIVALENCY DATE 1 Nov 1984

TEST SAMPLE EAK EXPLOSIVE TIME

SAMPLE WEIGHT 22.68 kg (50 lb) TEMP.

IGN. SOURCE J2 BLASTING CAP HUMIDITY

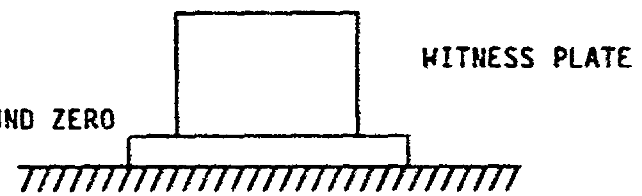
BOOSTER WT. 3.4 kg (7.5 lb) BAR. PRESS.

TEST NO. 44-84-08 WIND DIR.

CONTRACT NO. NAS 13-50 WIND VEL.

BOOSTER CHARGE
COMP. C4
CONICALLY SHAPED

L/D = 0.59



FIELD EVALUATION

CHANNEL NUMBER	DISTANCE meters (ft)	PEAK PRESSURE kPa (psi)	SCALED POSITIVE IMPULSE kPa msec/kg$^{1/3}$ (psi msec/lb$^{1/3}$)	TIME OF ARRIVAL (msec)
1	3.37	1163.5 (168.75)	178.9 (19.94)	1.68
2	(11.05)	1117.0 (162.00)	174.6 (19.46)	1.97
3	4.49	528.2 (76.61)	98.4 (10.96)	2.99
4	(14.74)	495.8 (71.90)	120.3 (13.41)	3.30
5	6.06	227.5 (33.00)	70.3 (7.83)	5.73
6	(19.89)	310.3 (45.00)	99.3 (11.07)	5.75
7	10.11	122.0 (17.70)	70.7 (7.88)	13.75
8	(33.16)	120.9 (17.54)	41.2 (4.59)	13.80
9	20.21	24.4 (3.54)	58.2 (6.49)	38.90
10	(66.31)	33.3 (4.88)	42.9 (4.78)	38.90
11	44.92	9.0 (1.30)	19.9 (2.22)	106.40
12	(147.36)	8.5 (1.24)	14.5 (1.62)	106.60

TEST TITLE TNT EQUIVALENCY DATE 6 Nov 1984

TEST SAMPLE EAK EXPLOSIVE TIME ______

SAMPLE WEIGHT 22.68 kg (50 lb) TEMP. ______

IGN. SOURCE J2 BLASTING CAP HUMIDITY ______

BOOSTER WT. 3.4 kg (7.5 lb) BAR. PRESS. ______

TEST NO. 45-84-01 WIND DIR. ______

CONTRACT NO. NAS 13-50 WIND VEL. ______

BOOSTER CHARGE
COMP. C4
CONICALLY SHAPED

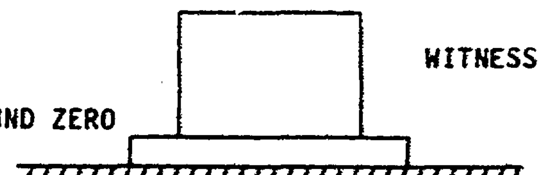
L/D = 0.59

INITIATOR

J-2 CAP

WITNESS PLATE

GROUND ZERO



NOT DRAWN TO SCALE

FIELD EVALUATION

CHANNEL NUMBER	DISTANCE meters (ft)	PEAK PRESSURE kPa (psi)	SCALED POSITIVE IMPULSE kPa msec/kg$^{1/3}$ (psi msec/lb$^{1/3}$)	TIME OF ARRIVAL (msec)
1	3.37	732.6 (106.25)	228.1 (25.42)	2.20
2	(11.05)	992.9 (144.00)	140.7 (15.68)	2.06
3	4.49	584.4 (84.76)	8.21 (9.15)	3.48
4	(14.74)	616.3 (89.38)	108.5 12.09)	3.27
5	6.06	220.1 (31.92)	83.1 (9.26)	6.00
6	(19.89)	234.3 (33.98)	88.3 (9.84)	5.72
7	10.11	82.1 (11.90)	63.7 (7.10)	14.25
8	(33.16)	135.8 (19.69)	54.5 (6.07)	14.00
9	20.21	23.6 (3.43)	25.0 (2.79)	40.50
10	(66.31)	24.1 (3.50)	7.2 (0.80)	40.00
11	44.92	8.5 (1.23)	9.4 (1.05)	109.20
12	(147.36)	9.6 (1.39)	11.6 (1.29)	108.20

TEST TITLE TNT EQUIVALENCY DATE 6 Nov 1984

TEST SAMPLE EAK EXPLOSIVE TIME

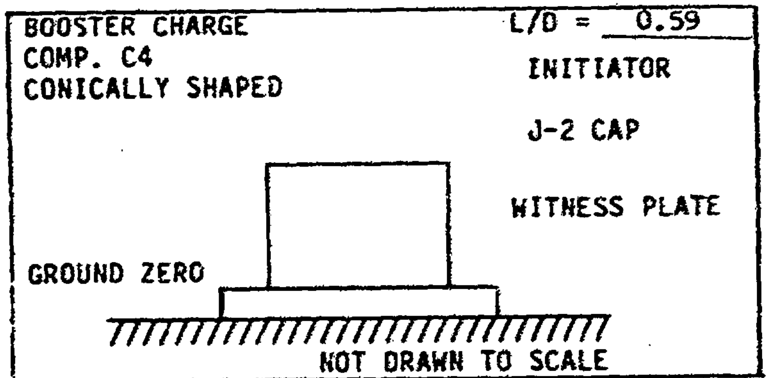
SAMPLE WEIGHT 22.68 kg (50 lb) TEMP.

IGN. SOURCE J2 BLASTING CAP HUMIDITY

BOOSTER WT. 3.4 kg (7.5 lb) BAR. PRESS.

TEST NO. 45-84-02 WIND DIR.

CONTRACT NO. NAS 13-50 WIND VEL.



FIELD EVALUATION

CHANNEL NUMBER	DISTANCE meters (ft)	PEAK PRESSURE kPa (psi)	SCALED POSITIVE IMPULSE kPa msec/kg$^{1/3}$ (psi msec/lb$^{1/3}$)	TIME OF ARRIVAL (msec)
1	3.37	991.2 (143.75)	215.7 (24.04)	1.92
2	(11.05)	910.1 (132.00)	143.6 (16.00)	1.90
3	4.49	494.5 (71.72)	106.6 (11.88)	3.43
4	(14.74)	462.2 (67.03)	93.3 (10.40)	3.29
5	6.06	229.7 (33.31)	84.6 (9.43)	6.02
6	(19.89)	273.4 (39.65)	93.3 (10.40)	5.89
7	10.11	75.0 (10.88)	71.5 (7.97)	14.55
8	(33.16)	125.9 (18.26)	44.0 (4.90)	14.00
9	20.21	31.9 (4.62)	43.3 (4.82)	40.40
10	(66.31)	25.0 (3.63)	11.4 (1.27)	39.60
11	44.92	8.1 (1.18)	21.2 (2.36)	109.40
12	(147.36)	9.2 (1.34)	11.3 (1.26)	108.20

TEST TITLE TNT EQUIVALENCY   DATE 7 Nov 1984

TEST SAMPLE EAK EXPLOSIVE   TIME ______

SAMPLE WEIGHT 22.68 kg (50 lb)   TEMP. ______

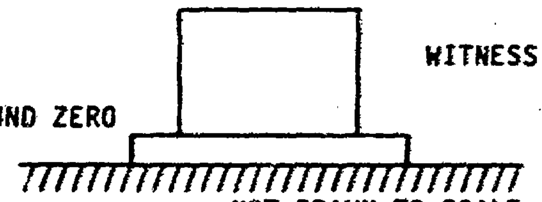
IGN. SOURCE J2 BLASTING CAP   HUMIDITY ______

BOOSTER WT. 3.4 kg (7.5 lb)   BAR. PRESS. ______

TEST NO. 45-84-03   WIND DIR. ______

CONTRACT NO. NAS 13-50   WIND VEL. ______

BOOSTER CHARGE   L/D = 0.59
COMP. C4
CONICALLY SHAPED



FIELD EVALUATION ______

CHANNEL NUMBER	DISTANCE meters (ft)	PEAK PRESSURE kPa (psi)	SCALED POSITIVE IMPULSE kPa msec/kg$^{1/3}$ (psi msec/lb$^{1/3}$)	TIME OF ARRIVAL (msec)
1	3.37	991.2 (143.75)	198.5 (22.12)	2.10
2	(11.05)	1199.7 (174.00)	137.7 (15.34)	2.01
3	4.49	494.5 (71.72)	102.9 (11.47)	3.44
4	(14.74)	462.2 (67.03)	111.2 (12.39)	3.52
5	6.06	208.8 (30.28)	105.7 (11.78)	6.02
6	(19.89)	258.5 (37.49)	90.0 (10.03)	6.14
7	10.11	80.6 (11.69)	72.0 (8.02)	14.65
8	(33.16)	103.1 (14.96)	41.4 (4.61)	14.45
9	20.21	35.2 (5.11)	22.6 (2.52)	40.30
10	(66.31)	23.9 (3.46)	17.7 (1.97)	40.20
11	44.92	8.9 (1.29)	17.8 (1.98)	108.80
12	(147.36)	8.8 (1.27)	22.8 (2.54)	109.60

APPENDIX C

SELECTED PHOTOGRAPHS

Figure C-1. Physical characteristics of EAK

Figure C-2. Typical pretest configuration for TNT equivalency testing of EAK in a cylindrical shipping container

Figure C-3. Typical posttest results for TNT equivalency testing of EAK explosive in a cylindrical shipping container

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